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Patella dislocation: an overview

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Abstract

Patella dislocation is one of the most common knee injuries, accounting for 3% of acute knee injuries. Despite its prevalence, patella dislocation is often missed, with a haemarthrosis often the only sign, albeit a non-specific one. A thorough history and examination are necessary to identify patella dislocation and its potential causes. Investigations should include cross-sectional imaging to evaluate both osseous and soft tissue structures in order to guide management. Management in the acute setting is normally non-operative, but damage to structural supports, osteochondral defects or recurrent dislocation should prompt consideration of operative treatment. Operative treatment should address the soft tissue stabilisers and/or osseus deformities that predispose to, or occur secondary to, patella dislocation.

Key words: Hypermobility; Medial patellofemoral ligament; Patella dislocation; Quadriceps tendon; Tibial tuberosity; Trochlear groove

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Background

Patella dislocation is one of the most common acute knee injuries, particularly in children and adolescents (Nwachukwu et al, 2016). It accounts for up to 3% of knee injuries and is usually traumatic in nature (Petri et al, 2015). The majority of these injuries spontaneously reduce, meaning that a haemarthrosis is often the only evidence that a dislocation has occurred (Duthon, 2015).

The primary stabilisers of the patella can be divided into static and dynamic structures (Loudon, 2016). In dislocation, one or more of these stabilisers can be injured or indeed have a deficiency that has led to the dislocation (Fithian et al, 2004). Management can be non-operative or operative, largely depending on the cause (Duthon, 2015).

This article reviews the mechanisms, diagnosis and treatment of this common injury and provides an approach to ensure that this does not go undiagnosed.

Anatomy

The patella is a sesamoid bone contained within the substance of the quadriceps muscle. The articular surface of the patella is formed of a larger lateral facet and smaller medial facet separated by a vertical ridge. It articulates with the trochlear groove of the femur, which is shaped to correspond to the patella facets, to form the patellofemoral joint. In addition to its congruent groove, the femur also has its lateral condyle higher than the medial to act as a restraint to lateral displacement (Brattström, 1964).

Two of the largest soft tissue attachments of the patella are the patella tendon and the quadriceps tendon. The force exerted by the quadriceps tendon on the patella is naturally lateral to the midline and, unchecked, can result in patella dislocation. Stability against excessive lateral pull is conferred by the medial patellofemoral ligament and vastus medialis oblique, both of which insert onto the medial aspect of the patella (Greiwe et al, 2010). Given the direction of pull of the quadriceps tendon, it is easy to see why deficiency or disruption of the medial patellofemoral ligament or vastus medialis oblique could result in patella dislocation and why most patella dislocations are lateral in direction (Figure 1).

Biomechanics

As the knee joint passes through its range of motion, so too does the patella. From a position of full extension, the patella lies just above the trochlear groove of the femur and slightly lateral to its centre (Loudon, 2016). As flexion begins, contact between the patella

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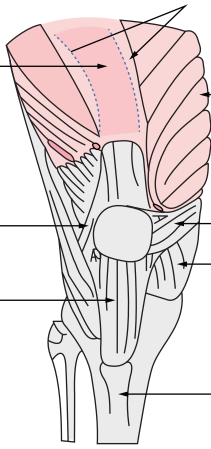

Figure 1. Key soft tissue structures around the patella.

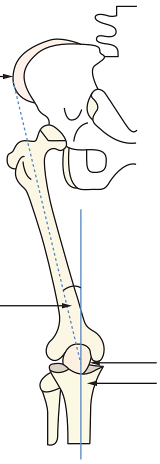

Figure 2. Q-angle measurement.

and the trochlear groove begins, starting with the lateral patella facet and corresponding femoral condyle. By the end of the first 30° of flexion, contact is more evenly distributed and both patella facets are in contact with the femoral condyles centred in the trochlear groove (Loudon, 2016). This pattern of contact between the patella and femur continues to increase until deep flexion is reached; at this point, only the edges of the patella facets are in contact with the femur (Loudon, 2016).

The quadriceps angle (Q-angle) plays an important role in patellar instability. It is the angle between the load vectors of the quadriceps tendon and patellar tendon (Cooney et al, 2012) (Figure 2). In practice, this angle represents the line of the pull of the quadriceps on the patella. This means that as the Q-angle increases, the lateral force applied to the patella increases, as does the risk of lateral patella dislocation (Cooney et al, 2012).

Predisposing factors

An understanding of the basic anatomy and biomechanics of the patella and patellofemoral joint makes it easier to explore predisposing factors for patella dislocation. These can broadly be divided into bony abnormalities and soft tissue abnormalities.

Bony abnormalities of the femur

Trochlear dysplasia is an established cause of patella dislocation (Beaufils et al, 2012). As explored earlier, two factors that protect against patella dislocation are the congruency of the trochlear groove of the femur and the height of the lateral femoral condyle. Dejour et al (1994) described four types of trochlear dysplasia which range from a loss of trochlear

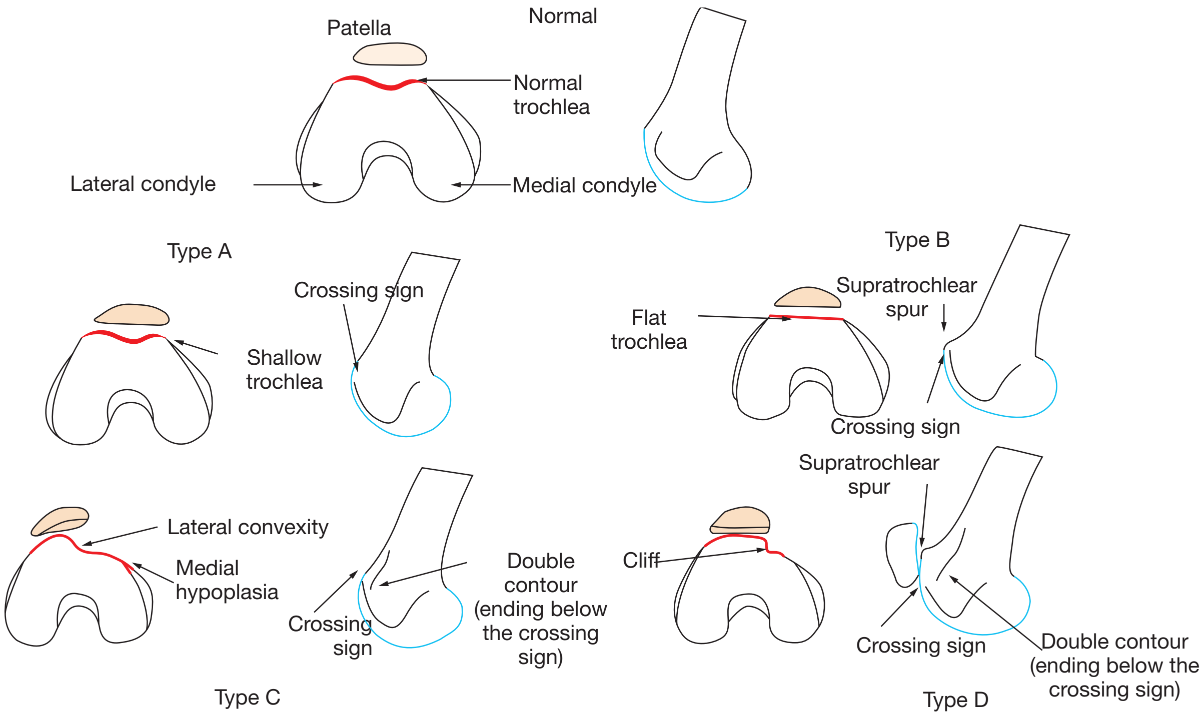

Figure 3. Classification of trochlear dysplasia. Type A: axial view – normal-shaped trochlea with a shallow trochlear groove; lateral view – crossing sign. Type B: axial view – flattened or convex trochlea; lateral view – crossing sign and supratrochlear spur. Type C: axial view – trochlear facet asymmetry with too high lateral condyle and hypoplastic medial femoral condyle; lateral view – crossing sign and double contour sign. Type D: type C axial view features with a vertical link between facets ('cliff pattern'); lateral view – crossing sign, double contour sign and supratrochlear spur.

depth to abnormalities of the femoral trochlear (Figure 3). Each type results in a tendency of the patella to displace laterally and hence increase the risk of dislocation.

Additionally, hypoplasia of the lateral femoral condyle, removing the restraining action of it, can contribute to patella dislocation (Biedert et al, 2011).

Bony abnormalities of the patella

While the femur is the greatest contributor to the bony stability of the patella, abnormalities of the patella itself can also increase the risk of dislocation. Patella alta is a condition in which the natural position of the patella is higher than usual (Gulati et al, 2018). Owing to this higher starting point, the amount of flexion needed to engage the patella in the trochlear groove is greater and the amount of contact between surfaces is reduced (Gulati et al, 2018). This results in less stability for a greater range of motion than is normal, thus increasing the risk of patella dislocation.

There are several methods for assessing the presence of patella alta; one of the most widely used is the Insall–Salvati index (Giovagnorio et al, 2017) (Figure 4a). This can be measured on a lateral X-ray of the 30° flexed knee with the ratio of the patella tendon length (measured from the lower pole of the patella to the tendon's insertion on the tibial tuberosity) to patella length. Patella alta is classed as an Insall–Salvati index of >1.2. An alternative method is the Caton–Deschamps index (Figure 4b). Much like the Insall–Salvati index, this involves X-ray of the flexed knee, and measurement of the ratio of the distance from the inferior aspect of the patella's articular surface to the anterior tibial plateau and the length of the articular surface of the patella. Values greater than 1.2 are suggestive of patella alta (Biedert and Tscholl, 2017). Both Insall–Salvati and Caton–Deschamps indices can also be evaluated using cross-sectional imaging.

Other bony abnormalities

The position of the tibial tuberosity also contributes to lateral patella dislocation. In some patients with patella dislocation, the tibial tuberosity is lateralised (Balcarek et al, 2011). The distance between this lateralised tibial tuberosity and the trochlear groove (TT–TG

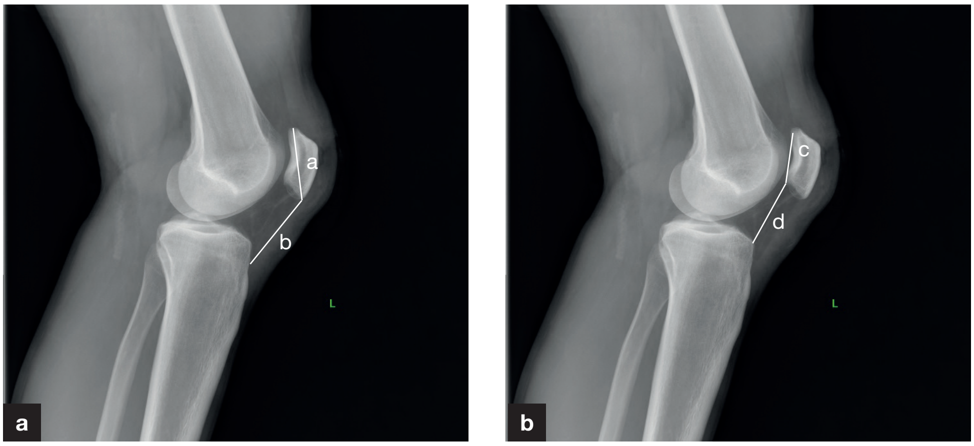

Figure 4. a. Insall–Salvati index, where a is the patella length and b is the patella tendon length. b/a >1.2 suggests patella alta. b. Caton–Deschamps index, where c is patella articular surface length and d is the distance from the inferior aspect of the patella articular surface to the anterior tibial plateau. d/c >1.2 suggests patella alta.

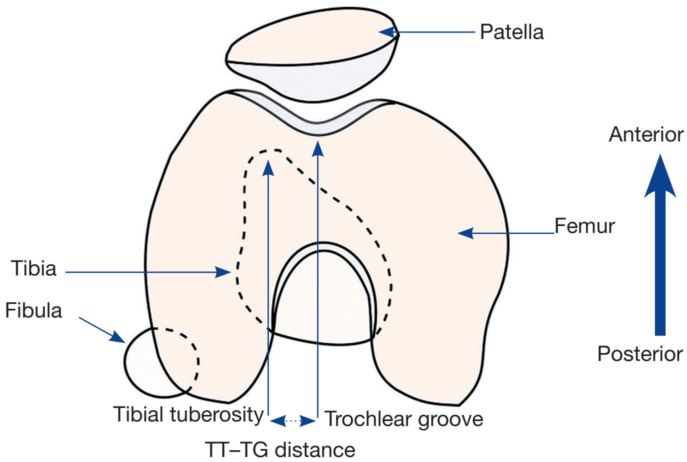

Figure 5. Axial views of the femoral condyles and tibial tuberosity demonstrating measurement of the tibial tuberosity–trochlear groove (TT–TG) distance.

distance) represents the quadriceps vector and hence the lateral force applied to the patella during motion (Balcarek et al, 2011). The TT–TG distance is commonly measured using a computed tomography scan and can be measured using superimposed axial images of the tibial tuberosity and femoral condyles. First a tangential line is drawn along the posterior femoral condyles. Perpendicular lines bisecting the tibial tuberosity, at its most anterior point, and trochlear groove, at its deepest point, are then drawn from this line. The distance between the latter two lines is the TT–TG distance (Figure 5). Distances of >20 mm are implicated in patellar instability (Song et al, 2016).

Soft tissue abnormalities

The medial patellofemoral ligament and vastus medialis oblique are the two greatest soft tissue contributors to patella stability. The medial patellofemoral ligament is a static stabiliser and connects the medial epicondyle of the femur to the medial edge of the patella (Zaffagnini et al, 2013). Following traumatic lateral dislocation of the patella, up to 96% of patients will have deficiency of the medial patellofemoral ligament (Kyung and Kim, 2015). The medial patellofemoral ligament is the sole stabiliser of the patella during the initial 20–30° of flexion (Zaffagnini et al, 2013). Damage to this structure results in smaller amounts of force being required to cause lateral patella displacement (Zaffagnini et al, 2013).

Vastus medialis oblique strengthening is often used following a first time patella dislocation. Weakness or atrophy of the vastus medialis oblique is associated with increased lateral patella movement during the initial stages of flexion, but it is less clear whether this represents cause or effect (Balcarek et al, 2014). As the medial patellofemoral ligament is formed from some of the fibres of the vastus medialis oblique, and the vastus medialis oblique is the main dynamic stabiliser of the patella, it stands to reason that vastus medialis oblique deficiency is a contributor to lateral patella dislocation. Equally, should the strength of the vastus lateralis exceed the vastus medialis oblique, such that lateral pull is increased, the risk of lateral patella dislocation increases (Lai et al, 2000).

Other factors

Hypermobility has also been recognised as a cause of patella dislocation among other musculoskeletal complaints (Carter and Sweetnam, 1958). Laxity of the static stabiliser of the patellofemoral joint, namely the medial patellofemoral ligament, would account for this association.

Patella dislocations can occur in any patient, but some groups are more likely to sustain patella dislocation than others. Sporting activity and younger age increase the risk of patella dislocation (Fithian et al, 2004; Lewallen et al, 2015; Sanders et al, 2018; Vermeulen et al, 2019). Most studies agree that there is a similar incidence of patella dislocation in male and female patients (Stefancin and Parker, 2007; Lewallen et al, 2015; Sanders et al, 2018) although Fithian et al (2004) suggested a female preponderance.

Mechanism of injury

There have been many suggested mechanisms of patella dislocation. The most widely recognised is that of a valgus force with the knee in flexion (Duthon, 2015). Other mechanisms proposed include extending the knee from a flexed position, for example standing from a seated position, and deep flexion from a partially flexed position (Nikku et al, 2009). Description of these mechanisms should raise suspicion for patella dislocation.

Diagnosis

Clinical history is important in the diagnosis of patella dislocation. Patients often report feeling a ‘pop’ in their knee followed by immediate swelling after an innocuous trauma (Duthon, 2015). As spontaneous reduction usually occurs before presentation, this can make the diagnosis difficult. A history of previous dislocation, family history or a diagnosis of hypermobility should all raise the suspicion of patella dislocation (Duthon, 2015).

Haemarthrosis can often be the only sign of patella dislocation, especially in those that have reduced spontaneously. However, as a haemarthrosis can occur in many injuries of the knee, a thorough history and high index of suspicion must be maintained. Other causes of haemarthrosis include bony injuries such as intra-articular fracture of the patella, femur or tibia, soft tissue injuries such as cruciate ligament rupture or meniscal tear or minor trauma in the presence of coagulopathy (Shaerf and Banerjee, 2008).

The pain and swelling that can be present as a result of patella dislocation often make clinical examination difficult, if not impossible. Visual inspection, to look for quadriceps wasting, particularly vastus medialis oblique, and evidence of patella alta may be all that is possible on initial assessment. If physical assessment is tolerated, tenderness at the medial epicondyle of the femur (Bassett’s sign) or apprehension on the application of lateral force to the patella (apprehension test) are indicators of possible patella dislocation (Smith et al, 2008). The J-sign can also be useful in determining the presence of patellar maltracking. In patients with a positive J-sign, the patella is laterally subluxed during active extension of the knee, suddenly shifting medially into the trochlea during early flexion, its path thus resembling an inverted J (Best et al, 2020). An increase in the Q-angle, normally 10–15° in men and 15–20° in women (Smith et al, 2008), may also aid in the diagnosis of patella dislocation. Assessment for hypermobility should also be considered, this can be performed using the nine-point Beighton score (Beighton et al, 1973). The score has five elements with a total of nine points available (**Table 1**). The greater the score, the greater the likelihood of hypermobility.

Table 1. Beighton score (1 point is given per element)		
Element	**Right**	**Left**
Hyperextension of the little finger beyond 90°		
Hyperextension of the elbow beyond 10°		
Hyperextension of the knee beyond 10°		
Apposition of the thumb to the forearm		
Flexion of the trunk with the knees fully extended and the palms flat on the floor	Y / N	
Total	/ 9	

Plain radiographs of the knee can be useful in excluding other injuries as the cause of the presentation. However, the presence of a fracture, particularly of the lateral femoral condyle, can be concurrent to patella dislocation (Duthon, 2015). A Merchant view, with the knee in 45° of flexion, may demonstrate an osteochondral defect of the medial patella facet (Stefancin and Parker, 2007). The presence of an osteochondral defect following patella dislocation can vary from 24% to 49% (Stefancin and Parker, 2007; Guerrero et al, 2009). Signs of trochlear dysplasia can also be seen on a true lateral radiograph of the knee (Figure 3). These include the crossing sign, where, as a result of flattening of the trochlear groove, the line representing the deepest part of the trochlear groove crosses the anterior border of the femoral condyles; the double contour sign, seen as a double line anterior to the condyles which is indicative of medial femoral condyle hypoplasia, and a supratrochlear spur, which is a prominence of the trochlea that can affect patella tracking (Batailler and Neyret, 2018).

In the acute setting, a computed tomography scan may be useful in demonstrating the extent of any fracture, as this is not always apparent on plain radiographs. Beyond the acute setting, it can be useful in assessing trochlear dysplasia, patellar tilt and the dynamic movements of the patella (Duthon, 2015). Magnetic resonance imaging is of greater use in the assessment of soft tissue and cartilage defects. Deficiency in the medial patellofemoral ligament or vastus medialis oblique as well as osteochondral defects can be detected, and this can help guide the management.

Both computed tomography and magnetic resonance imaging scans can be reliably used to assess the TT–TG distance. It has been suggested that a TT–TG distance greater than 20 mm is associated with a greater risk of patella dislocation (Balcarek et al, 2011).

Non-operative management

Traditionally, following acute patella dislocation, a period of immobilisation has been the norm, by splinting or casting the limb, followed by intensive physiotherapy, with a focus on vastus medialis oblique strengthening (Duthon, 2015). Vastus medialis oblique exercises are shown in Figure 6. A systematic review of conservative management was unable to determine the best method owing to the sparsity and quality of studies on the subject (Vermeulen et al, 2019). However, the rate of recurrence in non-operatively managed patella dislocation is as high as 69% in children (Nwachukwu et al, 2016) and 52% in adults (Tsai et al, 2012). Lewallen et al (2015) further stratified the risk of recurrence at 5 years in conservatively managed patients as 11% in those with isolated patella alta, 23% in those with isolated trochlea dysplasia and 27% in those younger than 25 years of age; having all three resulted in a 70% risk of recurrence. This has led to an expansion in the indications for surgical management from osteochondral defect alone to wider indications (Stefancin and Parker, 2007).

Operative treatment

As stated, the indications for operative management of patella dislocation have increased. Patients should be considered for operative management if there is evidence of osteochondral

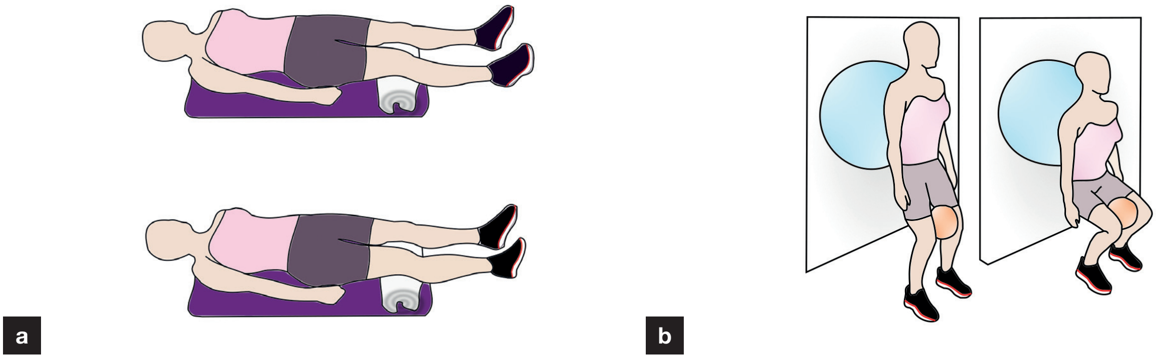

Figure 6. a. Vastus medialis oblique exercise 1: contract the vastus medialis oblique by squeezing the inner thigh muscle (blue arrow) and slowly lifting the leg off the floor (red arrow). b. Vastus medialis oblique exercise 2: while resting on a Swiss ball (blue) and placing a medicine ball between the legs (orange), squeeze the medicine ball and slowly squat. Go down until the hips are perpendicular to, but slightly forward of, the feet, then return back up to the start position.

defect, evidence of disruption of the medial patellofemoral ligament, failure to improve with non-operative management, further dislocation or a laterally subluxed patella (Stefancin and Parker, 2007).

As over 100 procedures have been described for the operative management of patella dislocation, this article describes those commonly used. These are broadly categorised into procedures for the trochlear, for the medial patellofemoral ligament, for the tibial tuberosity and for the lateral structures.

Trochlear procedures

The mainstay of treatment for the dysplastic trochlear groove is trochleoplasty. The purpose of this is to correct the deformity by a combination of widening and/or deepening of the trochlear groove to restore some degree of congruency (Beaufils et al, 2012). These procedures can either be performed open or arthroscopically.

Medial patellofemoral ligament procedures

There are two types of procedure to be considered in addressing medial patellofemoral ligament deficiency, repair and reconstruction. Depending on the amount of damage, repair may be the preferred option and demonstrates lower rates of further dislocation than non-operative management (Nwachukwu et al, 2016). Medial patellofemoral ligament reconstruction, when damage to the native medial patellofemoral ligament is too great to salvage, can be performed using allogenous or autogenous tendon grafts (Petri et al, 2015). Both procedures are designed to restore the integrity of the main static stabiliser of the patella.

Tibial tuberosity procedures

Malposition of the tibial tuberosity such that the TT–TG distance exceeds 20 mm requires surgical correction, especially in the presence of recurrent dislocation. As the tibial tuberosity is usually lateralised in patella dislocation, tibial osteotomy with medialisation is usually performed to reduce the lateral forces acting on the patella (Duthon, 2015).

Lateral soft tissue procedures

In some patients, an imbalance between the medial stabilisers (vastus medialis oblique and medial patellofemoral ligament) and the lateral retinaculum is thought to exist. To address this, the concept of a lateral retinacular release is that by reducing the imbalance, there is less lateral displacement of the patella and hence a lower likelihood of patella dislocation (Clifton et al, 2010).

Complications

Complications following conservatively managed patella dislocation are rare although, compared with surgically managed patients, further dislocation is more common (Longo

Key points

- Unlike many other dislocations, patella dislocation is frequently missed as spontaneous reduction often occurs before presentation to healthcare professionals.
- While a non-specific finding, a haemarthrosis of the knee alongside a history suggestive of patella dislocation should prompt further investigation.
- Osseous abnormalities, including shallow trochlea groove, lateral femoral condyle dysplasias, high riding patella (patella alta) and mispositioned tibial tuberosity, can predispose to patella dislocation.
- Soft tissue abnormalities, including medial patellofemoral ligament deficiency and vastus medialis oblique deficiency, can predispose to patella dislocation.
- While acute management is usually non-operative, damage to the medial patellofemoral ligament, osteochondral defects, identified structural abnormality or recurrent dislocation should prompt consideration of operative treatment.

et al, 2017). Complications following surgery include wound infection, haematoma, deep vein thrombosis, nerve palsy, knee stiffness, pain, instability and patella fracture (Arshi et al, 2016; Clark et al, 2017; Longo et al, 2017).

Return to sport

As the majority of patella dislocations occur during sporting activities, it stands to reason that patients would want an indication of when they could safely return to sports. Given the heterogeneity of treatment options, the timing of return to sport is difficult to quantify. However, up to 60% of patients with a first time patella dislocation return to their pre-morbid activity levels irrespective of treatment modality (Ménétrey et al, 2014).

Conclusions

This article provides a comprehensive overview of patella dislocation. By exploring the anatomy and biomechanics of the patella and patellofemoral joint, the causes of patella dislocation can be better understood. In the initial management of patella dislocation, non-operative management may be considered in the absence of damage to the key stabilisers of the patella. When pursuing an operative management approach, this should address the underlying abnormality, with procedures used in isolation or in combination with each other.

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Conflicts of interest

The authors declare that they have no conflicts of interest

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Curriculum checklist

This article addresses the following requirements from the core surgical training curriculum:

- Basic sciences – knowledge – applied anatomy
- The clinical method in surgical practice
- Core specialty modules – trauma and orthopaedic surgery

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